

What is claimed is:

1. An image processing method of calculating, for
2 an original image formed from a plurality of original
3 pixels arrayed in a matrix along X- and Y-coordinate
4 axes perpendicular to each other, a new pixel value at a
5 desired pixel position by interpolation operation using
6 pixel values of interpolation original pixels formed
7 from a plurality of original pixels within a
8 predetermined range from the desired pixel position, and
9 interpolation coefficients corresponding to the
10 interpolation original pixels, thereby generating a new
11 image obtained by image-processing the original image,
12 comprising:
13 equally dividing a square submatrix formed
14 from 2 x 2 adjacent original pixels into small square
15 regions along the X- and Y-coordinate axes, setting
16 approximate points at vertexes of the regions, deriving,
17 on the basis of a predetermined interpolation function,
18 interpolation coefficients discretized at approximate
19 points within a predetermined range centered on an
20 arbitrary approximate point, calculating interpolation
21 coefficients normalized so as to adjust a sum of
22 coefficient values of interpolation coefficients used
23 for one interpolation operation among the interpolation
24 coefficients to 2^k (k is a positive integer), and
25 storing the normalized interpolation coefficients in a

26 coefficient buffer in advance;
27 temporarily storing an input original image in
28 an original image buffer;
29 calculating a new pixel position of each pixel
30 constituting a new image in accordance with
31 magnifications representing enlargement/reduction ratios
32 along the X- and Y-coordinate axes for the original
33 image;
34 selecting an approximate point closest to the
35 new pixel position as an approximate point of the new
36 pixel position from approximate points in a submatrix to
37 which the new pixel position belongs;
38 reading out interpolation coefficients
39 corresponding to the interpolation original pixels from
40 the coefficient buffer on the basis of positional
41 relationships between the selected approximate point and
42 interpolation original pixels within a predetermined
43 range from the approximate point;
44 performing interpolation operation by
45 product-sum operation between the pixel value of each
46 interpolation original pixel read out from the original
47 image buffer and each interpolation coefficient read out
48 from the coefficient buffer, thereby calculating a pixel
49 value at the approximate point; and
50 dividing the calculated pixel value by 2^k to
51 output a pixel value at the new pixel position.

2. A method according to claim 1, wherein when
the interpolation coefficient to be stored in the
coefficient buffer is to be normalized, each
interpolation coefficient derived by a real number from
the interpolation function is multiplied by 2^k , and
normalized to adjust a decimal part of a coefficient
value of the interpolation coefficient to not more than
a predetermined number of digit positions.

3. A method according to claim 1, wherein when
the interpolation coefficient to be stored in the
coefficient buffer is to be normalized, each
interpolation coefficient derived by a real number from
the interpolation function is multiplied by 2^k , and
integerized so as to integerize the interpolation
coefficient.

4. A method according to claim 3, wherein when a
sum of coefficient values of interpolation coefficients
used for one interpolation operation among integerized
interpolation coefficients does not become 2^k in
integerizing interpolation coefficients to be stored in
the coefficient buffer, one of the interpolation
coefficients before integerization is
incremented/decremented so as to adjust the sum to 2^k ,
and interpolation coefficients are sequentially
incremented/decremented from an interpolation

11 coefficient having the lowest increment/decrement ratio.

5. A method according to claim 1, wherein a
2 number used to divide the submatrix along the X- and
3 Y-coordinate axes is 2^n (n is an integer of not less
4 than 2).

6. A method according to claim 1, wherein
2 the coefficient buffer stores interpolation
3 coefficients corresponding to positional relationships
4 along one of the X- and Y-coordinate axes in the
5 positional relationships between the approximate point
6 and the interpolation original pixels, and
7 in interpolation operation, the interpolation
8 coefficients along said one coordinate axis are shared
9 between the X- and Y-coordinate axes, interpolation
10 coefficients corresponding to the positional
11 relationships between the approximate point and the
12 interpolation original pixels along the X-coordinate
13 axis are read out from the coefficient buffer,
14 interpolation coefficients corresponding to the
15 positional relationships between the approximate point
16 and the interpolation original pixels along the
17 Y-coordinate axis are read out from the coefficient
18 buffer, and two interpolation coefficients along the
19 X- and Y-coordinate axes for the same interpolation
20 original pixel are accumulated to obtain an

21 interpolation coefficient for each interpolation
22 original pixel.

7. A method according to claim 1, wherein
2 the coefficient buffer independently stores X
3 interpolation coefficients corresponding to positional
4 relationships along the X-coordinate axis, and X
5 interpolation coefficients corresponding to positional
6 relationships along the Y-coordinate axis in the
7 positional relationships between the approximate point
8 and the interpolation original pixels, and
9 in interpolation operation, the interpolation
10 coefficients corresponding to the positional
11 relationships along the X-coordinate axis are read out
12 from the coefficient buffer, the interpolation
13 coefficients corresponding to the positional
14 relationships along the Y-coordinate axis are read out
15 from the coefficient buffer, and two interpolation
16 coefficients along the X- and Y-coordinate axes for the
17 same interpolation original pixel are accumulated to
18 obtain an interpolation coefficient for each
19 interpolation original pixel.

8. A method according to claim 1, wherein
2 of interpolation coefficients calculated by a
3 symmetrical interpolation function centered on the
4 approximate point, only interpolation coefficients in

5 one of directions from the approximate point are stored
 6 as interpolation coefficients to be stored in the
 7 coefficient buffer, and
 8 in interpolation operation, an interpolation
 9 coefficient in said one direction from the approximate
 10 point is selected from the interpolation coefficients in
 11 the coefficient buffer in accordance with a positional
 12 relationship between the approximate point and the
 13 interpolation coefficient, and an interpolation
 14 coefficient in a direction opposite to said one
 15 direction is selected from the interpolation
 16 coefficients in the coefficient buffer in accordance
 17 with a positional relationship obtained by
 18 sign-inverting the positional relationship between the
 19 approximate point and the interpolation coefficient.

9. A method according to claim 1, wherein when
 2 the approximate point coincides with a position of an
 3 arbitrary interpolation original pixel, an interpolation
 4 coefficient with which all interpolation coefficients
 5 corresponding to other interpolation original pixels
 6 become 0 is used as an interpolation coefficient to be
 7 stored in the coefficient buffer.

10. A method according to claim 1, wherein a
 2 reference original pixel serving a reference among four
 3 original pixels constituting a submatrix to which the

4 approximate point belongs is specified on the basis of
5 an integral part of a position of the approximate point
6 obtained on the assumption that a distance between the
7 original pixels is 1, and pixel values of interpolation
8 original pixels used for one interpolation operation are
9 read out from the coefficient buffer on the basis of the
10 reference original pixel.

11. A method according to claim 10, wherein a
2 positional relationship between the approximate point
3 and the reference original pixel is calculated based on
4 a decimal part of the position of the approximate point
5 obtained on the assumption that the distance between the
6 original pixels is 1, and coefficient values of
7 interpolation coefficients used for one interpolation
8 operation are read out from the coefficient buffer on
9 the basis of the positional relationship.

12. A method according to claim 1, wherein in
2 calculating a new pixel position of each pixel
3 constituting a new image, a coordinate value of the new
4 pixel position along one of X- and Y-coordinate axes is
5 calculated in accordance with a magnification along said
6 one coordinate axis, and a coordinate value of the new
7 pixel position along the other coordinate axis is
8 calculated by a predetermined function using the
9 coordinate value along said one coordinate axis as a

10 parameter.

13. An image processing apparatus for calculating,
2 for an original image formed from a plurality of
3 original pixels arrayed in a matrix along X- and
4 Y-coordinate axes perpendicular to each other, a new
5 pixel value at a desired pixel position by interpolation
6 operation using pixel values of interpolation original
7 pixels formed from a plurality of original pixels within
8 a predetermined range from the desired pixel position,
9 and interpolation coefficients corresponding to the
10 interpolation original pixels, thereby generating a new
11 image obtained by image-processing the original image,
12 comprising:

13 a coefficient buffer for storing in advance
14 interpolation coefficients calculated such that a square
15 submatrix formed from 2 x 2 adjacent original pixels is
16 equally divided into small square regions along the
17 X- and Y-coordinate axes, approximate points are set at
18 vertexes of the regions, interpolation coefficients
19 discretized at approximate points within a predetermined
20 range centered on an arbitrary approximate point are
21 derived on the basis of a predetermined interpolation
22 function, and the interpolation coefficients are
23 normalized so as to adjust a sum of coefficient values
24 of interpolation coefficients used for one interpolation
25 operation among the interpolation coefficients to 2^k (k

26 is a positive integer);
27 an original image buffer for temporarily
28 storing an input original image;
29 interpolation position operation means for
30 calculating a new pixel position of each pixel
31 constituting a new image in accordance with
32 magnifications representing enlargement/reduction ratios
33 along the X- and Y-coordinate axes for the original
34 image, selecting an approximate point closest to the new
35 pixel position as an approximate point of the new pixel
36 position from approximate points in a submatrix to which
37 the new pixel position belongs, and reading out
38 interpolation coefficients corresponding to the
39 interpolation original pixels from said coefficient
40 buffer on the basis of positional relationships between
41 the selected approximate point and interpolation
42 original pixels within a predetermined range from the
43 approximate point; and
44 interpolation operation means for performing
45 interpolation operation by product-sum operation between
46 the pixel value of each interpolation original pixel
47 read out from said original image buffer and each
48 interpolation coefficient read out from said coefficient
49 buffer, thereby calculating a pixel value at the
50 approximate point, and for dividing the calculated pixel
51 value by 2^k to output a pixel value at the new pixel
52 position.

14. An apparatus according to claim 13, wherein
 2 said coefficient buffer stores, in advance as the
 3 interpolation coefficient, an interpolation coefficient
 4 obtained by multiplying, by 2^k , each interpolation
 5 coefficient derived by a real number from the
 6 interpolation function, and normalizing the
 7 interpolation coefficient so as to adjust a decimal part
 8 of a coefficient value of the interpolation coefficient
 9 to not more than a predetermined number of digit
 10 positions.

15. An apparatus according to claim 13, wherein
 2 said coefficient buffer stores, in advance as the
 3 interpolation coefficient, an interpolation coefficient
 4 obtained by multiplying, by 2^k , each interpolation
 5 coefficient derived by a real number from the
 6 interpolation function, and integerizing the
 7 interpolation coefficient so as to integerize the
 8 interpolation coefficient.

16. An apparatus according to claim 15, wherein
 2 when a sum of coefficient values of interpolation
 3 coefficients used for one interpolation operation among
 4 normalized interpolation coefficients does not become 2^k ,
 5 said coefficient buffer stores, in advance as the
 6 interpolation coefficient, an interpolation coefficient

7 obtained by incrementing/decrementing one of the
8 interpolation coefficients before integerization so as
9 to adjust the sum to 2^k , and sequentially
10 incrementing/decrementing interpolation coefficients
11 from an interpolation coefficient having the lowest
12 increment/decrement ratio.

17. An apparatus according to claim 13, wherein
2 said coefficient buffer stores, in advance as the
3 interpolation coefficient, an interpolation coefficient
4 obtained by dividing the submatrix by 2^n (n is an
5 integer of not less than 2) along the X- and
6 Y-coordinate axes.

18. An apparatus according to claim 13, wherein
2 said coefficient buffer stores, in advance as
3 the interpolation coefficients, interpolation
4 coefficients corresponding to positional relationships
5 along one of the X- and Y-coordinate axes in the
6 positional relationships between the approximate point
7 and the interpolation original pixels, shares the
8 interpolation coefficients along said one coordinate
9 axis between the X- and Y-coordinate axes, outputs
10 interpolation coefficients corresponding to the
11 positional relationships between the approximate point
12 and the interpolation original pixels along the
13 X-coordinate axis, and outputs interpolation

14 coefficients corresponding to the positional
15 relationships between the approximate point and the
16 interpolation original pixels along the Y-coordinate
17 axis, and

18 said interpolation operation unit accumulates
19 two interpolation coefficients along the X- and
20 Y-coordinate axes for the same interpolation original
21 pixel, obtaining an interpolation coefficient for each
22 interpolation original pixel.

19. An apparatus according to claim 13, wherein
2 said coefficient buffer independently stores, in advance
3 as the interpolation coefficients, X interpolation
4 coefficients corresponding to positional relationships
5 along the X-coordinate axis, and X interpolation
6 coefficients corresponding to positional relationships
7 along the Y-coordinate axis in the positional
8 relationships between the approximate point and the
9 interpolation original pixels, outputs the interpolation
10 coefficients corresponding to the positional
11 relationships along the X-coordinate axis, outputs the
12 interpolation coefficients corresponding to the
13 positional relationships along the Y-coordinate axis,
14 and accumulates two interpolation coefficients along the
15 X- and Y-coordinate axes for the same interpolation
16 original pixel, obtaining an interpolation coefficient
17 for each interpolation original pixel.

20. An apparatus according to claim 13, wherein
2 said coefficient buffer stores, in advance as the
3 interpolation coefficients, only interpolation
4 coefficients in one of directions from the approximate
5 point among interpolation coefficients calculated by a
6 symmetrical interpolation function centered on the
7 approximate point, selects an interpolation coefficient
8 in said one direction from the approximate point from
9 the interpolation coefficients in said coefficient
10 buffer in accordance with a positional relationship
11 between the approximate point and the interpolation
12 coefficient, and selects an interpolation coefficient in
13 a direction opposite to said one direction from the
14 interpolation coefficients in said coefficient buffer in
15 accordance with a positional relationship obtained by
16 sign-inverting the positional relationship between the
17 approximate point and the interpolation coefficient.

21. An apparatus according to claim 13, wherein
2 when the approximate point coincides with a position of
3 an arbitrary interpolation original pixel, said
4 coefficient buffer stores, in advance as the
5 interpolation coefficient, an interpolation coefficient
6 with which all interpolation coefficients corresponding
7 to other interpolation original pixels become 0.

22. An apparatus according to claim 13, wherein
2 said interpolation position operation means specifies a
3 reference original pixel serving a reference among four
4 original pixels constituting a submatrix to which the
5 approximate point belongs, on the basis of an integral
6 part of a position of the approximate point obtained on
7 the assumption that a distance between the original
8 pixels is 1, and reads out pixel values of
9 interpolation original pixels used for one interpolation
10 operation from said coefficient buffer on the basis of
11 the reference original pixel.

23. An apparatus according to claim 22, wherein
2 said interpolation position operation means calculates a
3 positional relationship between the approximate point
4 and the reference original pixel on the basis of a
5 decimal part of the position of the approximate point
6 obtained on the assumption that the distance between the
7 original pixels is 1, and reads out coefficient values
8 of interpolation coefficients used for one interpolation
9 operation from said coefficient buffer on the basis of
10 the positional relationship.

24. An apparatus according to claim 13, wherein in
2 calculating a new pixel position of each pixel
3 constituting a new image, said interpolation position
4 operation means calculates a coordinate value of the new

5 pixel position along one of X- and Y-coordinate axes in
6 accordance with a magnification along said one
7 coordinate axis, and calculates a coordinate value of
8 the new pixel position along the other coordinate axis
9 by a predetermined function using the coordinate value
10 as a parameter.